FORM PTO-1390 (REV 11-2000)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 2490-17
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 10/070619
INTERNATIONAL APPLICATION NO. PCT/GB00/03483	INTERNATIONAL FILING DATE 08/09/2000	PRIORITY DATE CLAIMED 08/09/1999

TITLE OF INVENTION

SEMICONDUCTOR LASER DIODE WITH A DISTRIBUTED REFLECTOR

APPLICANT(S) FOR DO/EO/US

MASSARA, A. et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The U.S. has been elected by the expiration of 19 months from the priority date (Article 31).
5. A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☒ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has **NOT** expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 To 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information. PTO Form 1449

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JC13 Rec'd PCT/PTO 08 MAR 2002

U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/070619 unknown	PCT/GB00/03483	2490-17

21. ☒ The following fees are submitted:

	CALCULATIONS PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):	
-- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1040.00	
-- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $890.00	
-- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO $740.00	
-- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) $710.00	
-- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00	

ENTER APPROPRIATE BASIC FEE AMOUNT =						$	890.00
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).						$	130.00
CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE			
Total Claims	35	-20 =	15	X	$18.00	$	270.00
Independent Claims	1	-3 =	0	X	$84.00		0.00
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)					$280.00	$	0.00
CLAIM FEES ARE NOT BEING PAID AT THIS TIME				**TOTAL OF ABOVE CALCULATIONS =**		$	**1290.00**
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.							0.00
					SUBTOTAL =	$	**1290.00**
Processing fee of $130.00, for furnishing the English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)).					+		0.00
					TOTAL NATIONAL FEE =	$	**1290.00**
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). **$40.00** per property					+	$	0.00
Fee for Petition to Revive Unintentionally Abandoned Application ($1280.00 – Small Entity = $640.00)						$	0.00
					TOTAL FEES ENCLOSED =	$	**1290.00**
						Amount to be: refunded	$
						Charged	$

a. ☒ A check in the amount of $1290.00 to cover the above fees is enclosed.
b. ☐ Please charge my Deposit Account No. 14-1140 in the amount of $_____ to cover the above fees. A duplicate copy of this form is enclosed.
c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-1140. A duplicate copy of this form is enclosed.
d. ☒ The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

NIXON & VANDERHYE P.C.
1100 North Glebe Road, 8th Floor
Arlington, Virginia 22201-4714
Telephone: (703) 816-4000

SIGNATURE

Leonard C. Mitchard
NAME

29,009 REGISTRATION NUMBER

March 8, 2002 Date

The PTO did not receive the following listed item(s)
Received only $1020

609417

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

MASSARA, A. et al.

Atty. Ref.: 2490-17

Serial No. unknown

Group:

Filed: March 8, 2002

Examiner:

For: SEMICONDUCTOR LASER DIODE WITH A DISTRIBUTED REFLECTOR

* * * * * * * * * * *

March 8, 2002

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

PRELIMINARY AMENDMENT

In order to place the above-identified application in better condition for examination, please amend the application as follows:

IN THE SPECIFICATION

Please substitute the following paragraphs in the specification for corresponding paragraphs previously presented. A copy of the amended specification paragraphs showing current revisions is attached.

Page 1, before the first line, please insert as a separate paragraph:

This application is the US national phase of international application PCT/GB00/03483 filed 08 September 2000, which designated the US.

MASSARA, A. et al.
Serial No. **unknown**
IN THE CLAIMS

Please substitute the following amended claims for corresponding claims previously presented. A copy of the amended claims showing current revisions is attached.

3. An optical device as claimed in claim 1, wherein the two-dimensional array is in a plane parallel to the active layer and extends to a depth comparable to that of the active layer.

4. An optical device as claimed in claim 1, wherein the individual elements are holes.

7. An optical device, as claimed in claim 4, wherein the holes extend to a depth comparable to that of the active layer in a direction that is perpendicular to the plane parallel to the active layer.

8. An optical device, as claimed in claim 4, wherein the holes extend to a depth comparable to that of the active layer in a direction that is not perpendicular to the plane parallel to the active layer.

9. An optical device, as claimed in claim 4, wherein the holes are regions of different refractive index to that of the device structure.

10. An optical device, as claimed in claim 4, wherein the holes are regions of different gain or loss to that of the device structure.

11. An optical device, as claimed in claim 3, wherein the distributed reflector does not pierce the active region.

12. An optical device, as claimed in claim 3, wherein the distributed reflector partially pierces the active region.

13. An optical device, as claimed in claim 3, wherein the distributed reflector fully pierces the active region.

14. An optical device, as claimed in claim 1, wherein the distributed reflector is within the device.

17. An optical device as claimed in claim 1, with means for varying the electrical bias or biases applied to the device to obtain efficient optical emission in single wavelength operation.

19. An optical device, as claimed in claim 1, which is integrated with separate amplifying, absorbing or passive sections.

21. An optical device, as claimed in claim 1, with means for being pulsed

MASSARA, A. et al.
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REMARKS

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page(s) is captioned "**Version With Markings To Show Changes Made**."

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: _____
Leonard C. Mitchard
Reg. No. 29,009

LCM:ecb
1100 North Glebe Road, 8th Floor
Arlington, VA 22201-4714
Telephone: (703) 816-4000
Facsimile: (703) 816-4100

MASSARA, A. et al.
Serial No. **unknown**

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION

Page 1, before the first line, please insert as a separate paragraph:

This application is the US national phase of international application PCT/GB00/03483 filed 08 September 2000, which designated the US.

IN THE CLAIMS

3. An optical device as claimed in claim 1 ~~or 2~~, wherein the two-dimensional array is in a plane parallel to the active layer and extends to a depth comparable to that of the active layer.

4. An optical device as claimed in claim 1~~, 2 or 3~~, wherein the individual elements are holes.

7. An optical device, as claimed in ~~one of~~ claims ~~4 to 6~~, wherein the holes extend to a depth comparable to that of the active layer in a direction that is perpendicular to the plane parallel to the active layer.

8. An optical device, as claimed in ~~one of~~ claims ~~4 to 6~~, wherein the holes extend to a depth comparable to that of the active layer in a direction that is not perpendicular to the plane parallel to the active layer.

9. An optical device, as claimed in ~~one of~~ claims ~~4 to 8~~, wherein the holes are regions of different refractive index to that of the device structure.

10. An optical device, as claimed in ~~one of~~ claims ~~4 to 9~~, wherein the holes are regions of different gain or loss to that of the device structure.

11. An optical device, as claimed in ~~one of~~ claims ~~3 to 10~~, wherein the distributed reflector does not pierce the active region.

12. An optical device, as claimed in ~~one of~~ claims ~~3 to 10~~, wherein the distributed reflector partially pierces the active region.

13. An optical device, as claimed in ~~one of~~ claims ~~3 to 10~~, wherein the distributed reflector fully pierces the active region.

14. An optical device, as claimed in ~~any preceding~~ claim 1, wherein the distributed reflector is within the device.

17. An optical device as claimed in ~~any preceding~~ claim 1, with means for varying the electrical bias or biases applied to the device to obtain efficient optical emission in single wavelength operation.

19. An optical device, as claimed in ~~any preceding~~ claim 1, which is integrated with separate amplifying, absorbing or passive sections.

21. An optical device, as claimed in ~~a in any preceding~~ claim 1, with means for being pulsed by gain switching, Q-switching or mode-locking techniques.

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WO 01/18924

SEMICONDUCTOR LASER DIODE WITH A DISTRIBUTED REFLECTOR

Laser devices are commonly used as light sources, and it is of particular interest to be able to obtain laser sources which have high quality spectral performance for data communication applications. It is of particular interest to be able to manufacture such devices in a relatively simple and low cost way, to achieve a robust device. In particular it is advantageous to achieve a device with a highly selective optical spectrum, that is, a device which produces a large amplitude peak at one specific wavelength of output light.

One type of laser device which can be used as such a source is a Distributed Feedback (DFB) laser, and the related Distributed Bragg Reflector (DBR) laser. However, conventional techniques for manufacturing such devices include regrowth steps, which make the manufacturing relatively expensive.

The paper "1.5μm wavelength DBR lasers consisting of 3λ/4-semiconductor and 3λ/4-groove buried with benzocyclobutene", M.M.Raj, J. Wiedmann, Y. Saka, H. Yasumoto and S. Arai. *Electronics Letter, Vol.. 35, No. 16, pp. 1335-1337* describes a method of manufacturing deep etched (DBR) lasers. Since this technique involves etching into and across the active layer, the wave ceases to be guided within the etch, which means that these devices are likely to be inherently lossy.

The present invention relates to a laser device, with a ridge waveguide, with a distributed reflector on either side of the central ridge.

Since the light wave remains guided, this has the advantage that the device is relatively efficient.

Preferably, the reflector can be obtained by etching into the active layer on either side of the waveguide.

This has the advantage that the reflector can be obtained without using additional regrowth steps.

Preferably, the reflector takes the form of a two-dimensional pattern. This allows efficient reflection, while allowing the reflector to be contained in a relatively short length of the device.

For a better understanding of the present invention, and to show how it may be put into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a plan view of a laser device in accordance with the invention.

Figure 2 is an enlarged schematic illustration of a region of Figure 1.

Figure 3 is a cross-sectional view through the device of Figure 1.

Figure 4 illustrates the room temperature (20°C) CW optical spectra at 60mA for (a) pre-etch non-AR coated and (b) post-etch AR coated conditions of the device of Figure 1.

Figure 5 illustrates the post-etch room temperature (20°C) CW L-I characteristics of the device of Figure 1.

Figure 6 illustrates the post-etch, room temperature (20°C) variation of lasing wavelength with CW bias current for the device of Figure 1.

Figure 1 is a top plan view of a laser device in accordance with the invention. The device 2 is an InGaAsP-InP laser, with a ridge-waveguide 4. The device consists of seven 0.8% compressively strained quantum wells, and operates at a centre wavelength of ~1.29μm. The laser is 350μm long, and acts as a Fabry-Perot (F-P) laser. It is cleaved on both end facets 6,8. The laser is bonded junction side up on a temperature-controlled submount (not shown) and the output can be connected via a lensed fibre. The back

facet 6 is AR coated to 0.1%, in order to suppress the F-P modes.

Figure 3 is a cross-sectional view, taken on line A-A in Figure 1. As shown in Figure 3, the device has an active region 10 within the structure, with a silicon dioxide layer 12, having a metal layer 14 above it as the uppermost layers. The central ridge-waveguide has a width W of, for example, approximately 3μm, with etched channels of width X of approximately 8μm on either side of the ridge waveguide.

In accordance with the preferred embodiment of the invention, a distributed reflector structure is provided on either side of the central ridge waveguide, leaving the waveguide itself untouched.

In this illustrated embodiment of the invention, the distributed reflectors take the form of an etched 2D-lattice grating 18. The grating 18 is etched into the bottom surfaces 20 of the channels 16, over a section of the cavity. This section has a length L of approximately 50μm, and is located towards the back facet 6 of the device, for example approximately 50μm from the back facet.

Figure 2 is an enlarged view of the etched grating pattern in one of the channels 16. The array comprises a series of holes 22, etched through the top contact 14 to a depth which is comparable to the depth of the active region 10. In this illustrated embodiment, the holes 22 are arranged in a hexagonal array. That is, each hole away from the edge of the array is surrounded by six equally spaced holes. This separation a is of the order of 0.60-0.65μm, and the holes have a radius r such that the radius-to-pitch ratio r:a is 0.17, although it may be in the range of 0.17-0.33.

The grating pattern could also be a square array, or any pattern which provides a suitable reflector.

Preferably, the holes are etched to a depth which

is very close to, or, more preferably, into the active region.

Advantageously, the holes can be obtained by post-processing using any available etching technique, for example, focused ion bean etching (FIBE)or reactive ion etching (RIE), without requiring any subsequent regrowth. This has the advantage that the device can be manufactured relatively simply and inexpensively.

This structure has the further advantage that the holes, which act as the reflectors, provide a high refractive index contrast ratio between the holes and the material of the device, of approximately 1:3.5.

In order to improve passivation, it is possible to fill in the etched holes with a suitable material, such as benzocyclobutene (BCB), which reduces this ratio to approximately 1.5:3.5. However, this ratio is sufficiently large that a highly selective characteristic can be obtained, over a short etched length.

The post-etch performance of the device is characterised in terms of the optical spectra. Measurements are taken at room temperature (20°C) under CW bias conditions. Figure 4a shows the pre-etch spectrum before AR coating at 60mA. This is indicative of a typical multi longitudinal mode F-P structure. Figure 4b illustrates clearly that, after etching, the device lases in a single longitudinal mode. Purely single mode operation is maintained over the entire operating current range up to over 3 times threshold. A typical SMSR value of >30dB is measured.

In order to investigate the stability of the lasting wavelength, the light current characteristics under CW bias conditions are measured at room temperature. Figure 5 shows a linear response above threshold, with no kinks evident, indicating that mode-hopping does not occur. A slope efficiency of 0.09 W/A

is measured along with an output power of greater than 2.5mW at twice threshold current. At room temperature, a reduction in threshold current of 2mA was observed as a result of the etch.

Single mode operation is further evidenced in Figure 6, which shows the variation of peak wavelength with CW bias current at room temperature (20°C). From threshold up to 85mA, the lasing wavelength is found to vary linearly at 0.009nm/mA, indicating mode-hop-free operation. The device spectra remain single mode over this range. Single mode emission is found to vary at the rate of 0.08nm/°C around room temperature.

One possible use of the device of the invention is in an integrated device which has, say, four such laser sources on a single device, with the distributed reflector structures of the four sources being different, such that the integrated device can selectively provide a source at any of four wavelengths.

There is thus described a technique which allows manufacture of a single-contact, mode-hop-free single longitudinal mode laser operating CW at room temperature, and bit rates up to approximately 10 GHz, to be produced from a previously multi-mode Fabry-Perot ridge-waveguide device.

CLAIMS:

1. An optical device, comprising a laser diode having a ridge waveguide located above an active layer, and having a distributed reflector in the form of a lattice of individual elements, wherein the elements are arranged in a two-dimensional array on either side of the ridge waveguide.

2. An optical device as claimed in claim 1, wherein the distributed reflector comprises a structure in material above the active layer on either side of the ridge waveguide.

3. An optical device as claimed in claim 1 or 2, wherein the two-dimensional array is in a plane parallel to the active layer and extends to a depth comparable to that of the active layer.

4. An optical device as claimed in claim 1, 2 or 3, wherein the individual elements are holes.

5. An optical device as claimed in claim 4, wherein the holes are arranged in a hexagonal array.

6. An optical device as claimed in claim 4, wherein the holes are arranged in a square array.

7. An optical device, as claimed in one of claims 4 to 6, wherein the holes extend to a depth comparable to that of the active layer in a direction that is perpendicular to the plane parallel to the active layer.

8. An optical device, as claimed in one of claims 4 to 6, wherein the holes extend to a depth comparable to that of the active layer in a direction that is not perpendicular to the plane parallel to the active layer.

9. An optical device, as claimed in one of claims 4 to 8, wherein the holes are regions of different refractive index to that of the device structure.

10. An optical device, as claimed in one of

claims 4 to 9, wherein the holes are regions of different gain or loss to that of the device structure.

11. An optical device, as claimed in one of claims 3 to 10, wherein the distributed reflector does not pierce the active region.

12. An optical device, as claimed in one of claims 3 to 10, wherein the distributed reflector partially pierces the active region.

13. An optical device, as claimed in one of claims 3 to 10, wherein the distributed reflector fully pierces the active region.

14. An optical device, as claimed in any preceding claim , wherein the distributed reflector is within the device.

15. An optical device, as claimed in claim 14, wherein the distributed reflector is within a pumped region.

16. An optical device as claimed in claim 14, wherein the distributed reflector is within an un-pumped region.

17. An optical device as claimed in any preceding claim, with means for varying the electrical bias or biases applied to the device to obtain efficient optical emission in single wavelength operation.

18. An optical device, as claimed in claim 17, wherein the emission wavelength may be controlled/tuned.

19. An optical device, as claimed in any preceding claim, which is integrated with separate amplifying, absorbing or passive sections.

20. An optical device, as claimed in claim 19, where the amplifying or absorbing sections have gain/loss modulation.

21. An optical device, as claimed in any preceding claim, with means for being pulsed by gain switching, Q-switching or mode-locking techniques.

AMENDED SHEET

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number
WO 01/18924 A1

(51) International Patent Classification[7]: H01S 5/22, 5/12

(21) International Application Number: PCT/GB00/03483

(22) International Filing Date:
8 September 2000 (08.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9921445.4 8 September 1999 (08.09.1999) GB

(71) Applicant *(for all designated States except US)*: **UNIVERSITY OF BRISTOL** [GB/GB]; 3rd floor, Senate House, Tyndall Avenue, Bristol BS8 1TH (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MASSARA, Aeneas, Benedict** [GB/GB]; 8 Garthwood Close, West Bergholt, Colchester, Essex CO6 3EA (GB). **SARGENT, Laurence, John** [GB/GB]; Top Floor Flat, 11 Bellevue, Clifton, Bristol BS8 1DB (GB). **PENTY, Richard, Vincent** [GB/GB]; 55 Redland Road, Bristol BS6 6AG (GB). **WHITE, Ian, Hugh** [GB/GB]; 57 Coombe Park, Weston, Bath BA1 3NH (GB).

(74) Agent: **O'CONNELL, David, Christopher**; Haseltine Lake & Co., Imperial House, 15-19 Kingsway, London WC2B 6UD (GB).

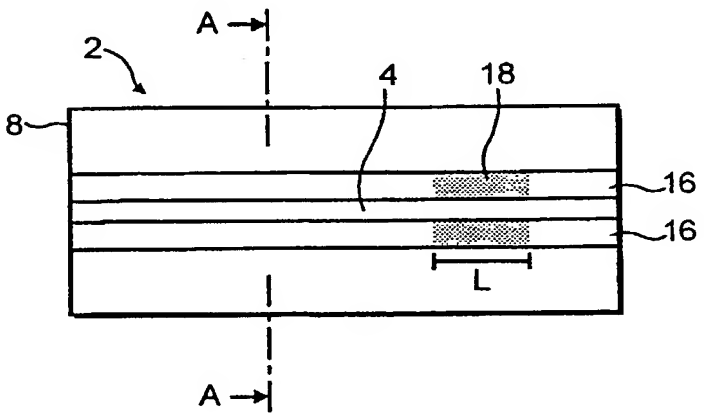
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SEMICONDUCTOR LASER DIODE WITH A DISTRIBUTED REFLECTOR



(57) Abstract: There is disclosed a laser diode with a ridge waveguide (14), in which a distributed reflector takes the form of an array of holes (22) etched into the surface of the device on either side of the central waveguide.

WO 01/18924 A1

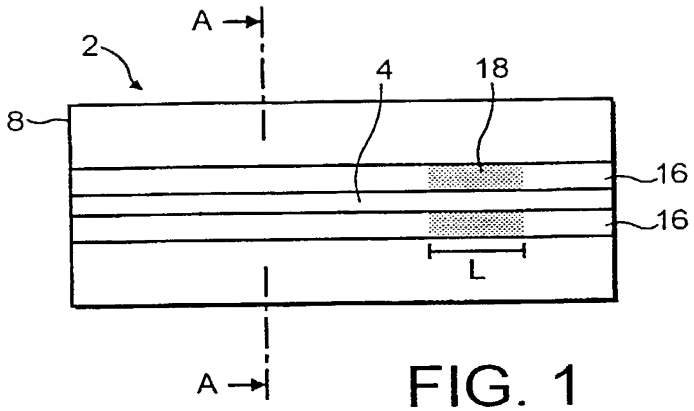


FIG. 1

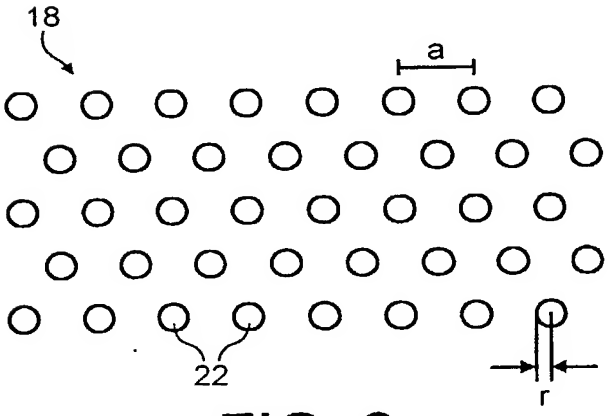


FIG. 2

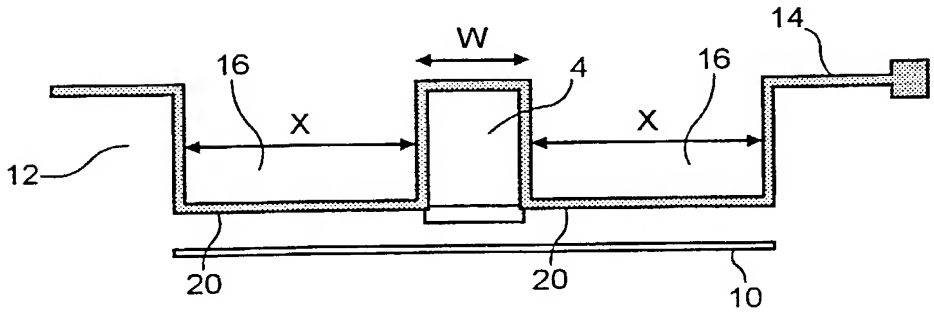
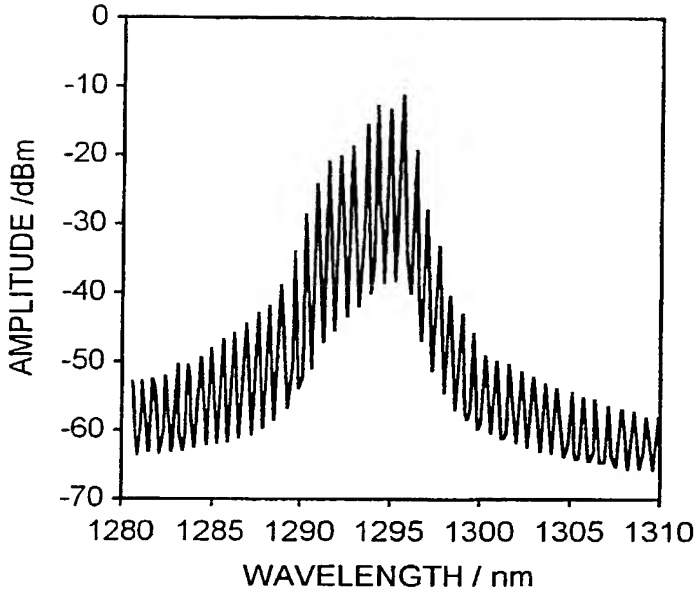


FIG. 3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-10
-20
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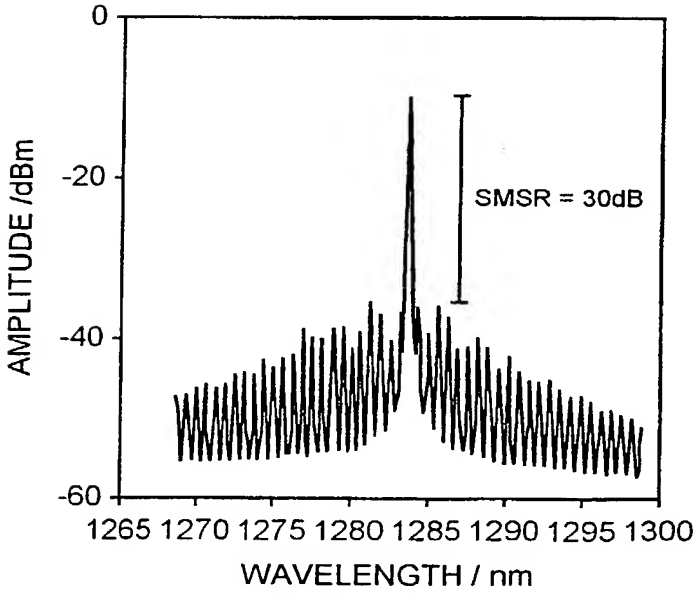
WAVELENGTH / nm

FIG. 4(a)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-20
-40
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AMPLITUDE /dBm
SMSR = 30dB
1265 1270 1275 1280 1285 1290 1295 1300
WAVELENGTH / nm

FIG. 4(b)

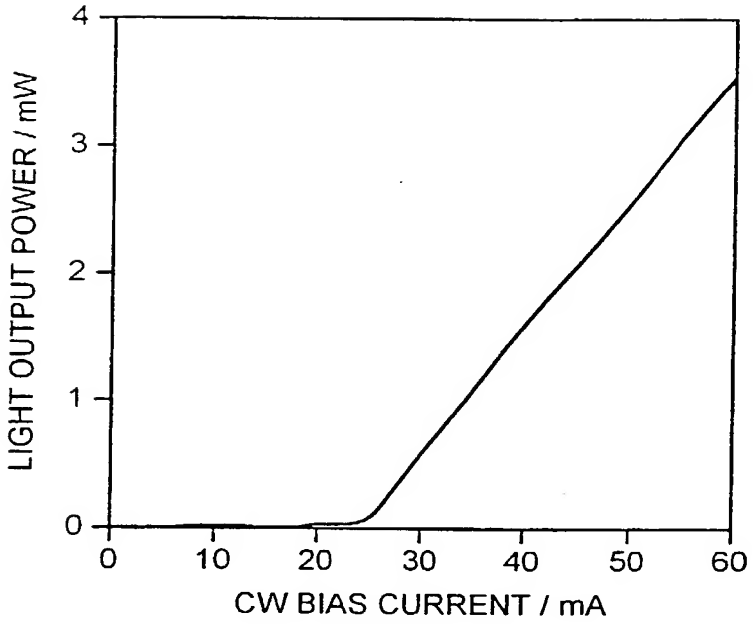
LIGHT OUTPUT POWER / mW
0
1
2
3
4
0
10
20
30
40
50
60
CW BIAS CURRENT / mA

FIG. 5

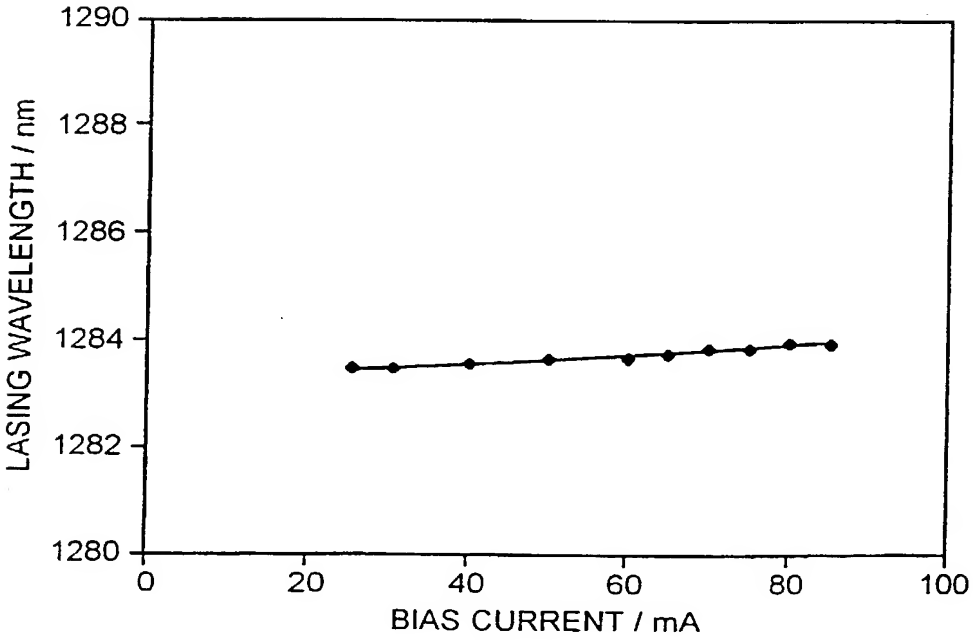
LASING WAVELENGTH / nm
1280
1282
1284
1286
1288
1290
0
20
40
60
80
100
BIAS CURRENT / mA

FIG. 6

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SEMICONDUCTOR LASER DIODE WITH A DISTRIBUTED REFLECTOR

the specification of which (check applicable box(s)):

☐ is attached hereto
☒ was filed on March 8, 2002 as U.S. Application Serial No. 10/070,619 (Atty Dkt. No. 2490-17)
☒ was filed as PCT International application No PCT/GB00/03483 on 08/09/2000
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1. Inventor's Signature: X A. B. Massara Date: 08/06/02
Inventor: Aengas (first) B. MI Massara (last) British (citizenship)
Residence: (city) ~~Essex~~ NORFOLK GBX (state/country) Great Britain
Mailing Address: ~~8 Cartlewood Close, West Bergholt, Colchester, Essex, Great Britain~~ 8 TUDOR AVENUE
(Zip Code) ~~CO6 3EA~~ ROYDON, DISS NORFOLK

2. Inventor's Signature: Date:
Inventor: Laurence (first) J. MI Sargent (last) British (citizenship)
Residence: (city) Marlow, Buckinghamshire (state/country) Great Britain
Mailing Address: 'Espere' Munday Dean, Marlow, Buckinghamshire, Great Britain
(Zip Code) SL7 3BU

☒ ***See attached sheet(s) for additional inventor(s) information!!***

3. Inventor's Signature: _____ Date: _____

Inventor: Richard (first) V. MI Penty (last) British (citizenship)

Residence: (city) Bristol (state/country) Great Britain

Mailing Address: 55 Redland Road, Bristol, Great Britain

(Zip Code) BS6 6AG

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Inventor: Ian (first) H. MI White (last) British (citizenship)

Residence: (city) Bath (state/country) Great Britain

Mailing Address: 57 Coombe Park, Weston, Bath, Great Britain

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Nixon & Vanderhye P.C. (10/99)
(Domestic Non-Assigned/Foreign) Page 1

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Residence: (city) Essex (state/country) Great Britain
Mailing Address: 8 Garthwood Close, West Bergholt, Colchester, Essex, Great Britain
(Zip Code) CO6 3EA

2. Inventor's Signature: L. Sargent Date: 30/04/2002
Inventor: Laurence (first) J. MI Sargent (last) British (citizenship)
Residence: (city) Marlow, Buckinghamshire GBX (state/country) Great Britain
Mailing Address: 'Espere' Munday Dean, Marlow, Buckinghamshire, Great Britain
(Zip Code) SL7 3BU

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2490-17
Serial No. 10/070,619

Nixon & Vanderhye P.C. (10/99
(Domestic Non-Assigned/Foreign)

3. Inventor's Signature: ______________________ Date: ____________

Inventor:	Richard	V.	Penty	British
	(first)	MI	(last)	(citizenship)

Residence: (city) Bristol (state/country) Great Britain
Mailing Address: 55 Redland Road, Bristol, Great Britain
(Zip Code) BS6 6AG

4. Inventor's Signature: ______________________ Date: ____________

Inventor:	Ian	H.	White	British
	(first)	MI	(last)	(citizenship)

Residence: (city) Bath (state/country) Great Britain
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614684

3. Inventor's Signature: X [signature] Date: 3/7/02

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Residence: (city) ~~Bristol~~ CAMBRIDGE (state/country) GBX Great Britain

Mailing Address: ~~55 Redland Road, Bristol, Great Britain~~ HOME FARM HOUSE, MEETING LANE,

(Zip Code) ~~BS6 6AG~~ LITLINGTON LANE, ROYSTON SG8 0QF GB

3

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Residence: (city)	Bristol		(state/country) Great Britain	
Mailing Address:	55 Redland Road, Bristol, Great Britain			
(Zip Code)	BS6 6AG			

4. Inventor's Signature: X I. H. White Date: 7/8/2

Inventor:	Ian (first)	H. MI	~~White~~ (last)	British (citizenship)
Residence: (city)	~~Bath~~ CAMBRIDGE		(state/country) Great Britain	
Mailing Address:	~~57 Coombe Park, Weston, Bath, Great Britain~~ 40 NEW SQUARE, CAMBRIDGE, UK			
(Zip Code)	~~BA1 3NH~~ CB1 1EZ			

I. H. W.

GBX

4/00